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A Study on the Swell Behaviour of Expansive Clays Reinforced with Saw Dust, Coir Pith & Marble Dust

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***Abstract*— Expansive type soil are which expand suddenly and start swelling when it comes in contact with moisture. Also the large amount of expansive soil is available all around the world which leads to a waste of land for construction uses. Soil stabilization is a process to treat a soil to maintain, alter or improve the performance of soil. Recently, how to utilize resources and how to preserve natural environment have become more serious problems in the world. In considering of increasing amount of the various kinds of industrial waste matter which are by-products from the industrial activity, it is necessary to dispose or utilize them for construction materials. In this study , the saw dust ,coir pith and marble dust are the stabilizing additive using for evaluation. As saw dust and coir pith causes environmental issues and they directly affect the ecosystem by bacterial growth, affecting aquatic life etc. Also increased production of marble waste powder has limited method of disposal as they are chemically active. So the proper application of these three materials have to be find out in engineering field. The evaluation involves the determination of the swelling potential of expansive soil in its natural state as well as when mixed with varying proportion(2%,4%,6%,8%,10%,12%) of saw dust, coir pith and marble dust .Also its strength is also checked using UCC method with the varying addition of saw dust ,coir pith and marble dust, inorder to check their suitability in applying light weight engineering applications like driveways, bunds, pavement etc**

Keywords*— *Black cotton soil, UCC,Swelling Pressure

I. INTRODUCTION

"Expansive soil is commonly known as black cotton soil because of their colour and their suitability for growing cotton." It starts swell or shrink excessively due to change in moisture content. When an engineering structure is associated with black cotton soil, it experiences either settlement or heave depending on the stress level and the soil swelling pressure. Design and construction of civil engineering structures on and with expansive soils is a challenging task for geotechnical engineers. The solution of this soil is stabilization with appropriate stabilizing agent. The black cotton soil contains high percentage of montomonillonite which renders high degree of expansiveness. These property results cracks in soil without any warning. The behaviour of black cotton soil is uncertain when subjected to moisture content. The strength properties of these soils change according to the amount of water contained in the voids of the soils.

Expansive soil deposits occur in the arid and semi arid regions of the world and are problematic to engineering structures because of their tendency to heave during wet season and shrink during dry season.

In India, the so-called black cotton soils cover a large area of approximately 200,000 square miles, in the heart of India. This soil is characterized by its extreme hardness when dry and with high swelling potential during the process of wetting. During the last few decades damage due to swelling action has been observed clearly in the semi arid regions in the form of cracking and breakup of pavements, roadways, building foundations, slab-on-grade members, and channel and reservoir linings, irrigation systems, water lines, and sewer lines.

One of the challenges faced by civil engineers is the design of foundation for sites having such soils. Expansive soils cause more damage to structures, particularly light buildings and pavements, than any other natural hazard, including earthquakes and floods.These soils pose problems to civil engineers in general and to geotechnical engineers in particular. They cause damage to structures founded in them because of their potential to react to changes in moisture regime. They undergo severe volume changes corresponding to changes in moisture content. Because of their potential to undergo volumetric changes, civil engineering structures such as foundations, retaining walls, pavements, airports, sidewalks, canal beds and linings are damaged. Various innovative practices have been devised to counteract the volume change problem and to safeguard the structures.

Most economical and effective method for stabilizing expansive soils is using admixtures that present change in volume. Many problems arise from the industrial development.

Generally, industrial waste causes many serious environment problems. So utilization of industrial waste in construction industry is the best way to dispose it. Using industrial waste in construction industry is beneficial in many ways such as disposal of waste, saving biodiversities, increasing soil properties like strength, reduce permeability, etc., preserve the natural soil and making economical structures.

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Soil stabilization is a procedure where natural or manufactured additives or binders are used to improve the properties of soils. Chemical additives, such as lime, cement and other chemical compounds have been used in expansive clays stabilization for many years with various degrees of success. In this study, saw dust, coir pith and marble dust will be utilized as waste materials in order to lower the swelling characters of such expansive soil.

II.LITERATURE REVIEW

Expansive soils are a worldwide problem that poses several challenges for civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures if not adequately treated. Expansive soils cause more damage to structures, particularly light buildings and pavements, than any other natural hazard, including earthquakes and floods .On the other hand industrial waste disposal is another main problem that the engineers facing. Marble dust, saw dust and coir pith are the locally available waste materials which do not have a good disposal method. Their incorporation when added to expansive soil has been studied in this paper. The following are the literature regarding the subject.

Aishwariya P S and Deepthy (2015) studies the effect of untreated and untreated coir pith on the compaction and the shear strength characteristics of the soil mixed with coir pith in varying percentages of 0% to 3% with an increment of 0.5%. A slight reduction in the dry density was observed with increase in percentage of coir pith. Whereas the treated coir pith soil mix shows increase in dry density as the pith content increases. It was observed that the optimum moisture content increases with increase in percentage of coir pith till 2% and thereafter decreases. For treated pith-soil mix, OMC decreases at first and then increases. A considerable increase in shear strength was observed after the chemical treatment of coir pith.

G Radhakrishnan, Dr.M Anjan Kumar and Dr.GVR Prasada Raju (2014) conducted laboratory experiments with the main objective, to study the swelling properties of the expansive subgrade soil treated with chemicals like Magnesium Chloride (MgCl2), Aluminum Chloride (AlCl3) and also by adding flyash in varying percentages. From their study, they concluded that the treatment of the expansive soil with Aluminum Chloride (AlCl3) and flyash at 1% and 10% respectively is more effective. There is a steep reduction in the Swelling Pressure value of the expansive soil in the beginning, up to 1% addition of chemicals and is nominal afterwards. The reduction in swell potential and swell pressure is significant upto the addition of 1% chemical and 10% flyash. The percentage reduction in swell potential is 63%, 68% and swell pressure is 69%, 73% respectively for $MgCl_2$, $AlCl_3$ chemicals with flyash. Finally, they concluded that the selected chemical and flyash combination is very effective in reducing the swell pressure, swell potential of the expansive soil considered for the addition of 1% chemical and 10% flyash is 54% and 64% respectively for $MgCl_2$.

Sachin N. Bhavsar and Ankit J. Patel (2014) conducted laboratory tests to resolve the problem of swelling and shrinkage in expansive soils using brick dust as a stabilizer. They replaced the soil by adding 50% brick dust to the soil. For the analysis of effect of stabilizer on soil, the comparison was done for properties of 100% black cotton soil and the combination of 50% clack cotton soil + 50% brick dust. From the results they obtained, they summarized that the engineering properties were improved after stabilizing it with Brick Dust by 50% of its dry weight. It has shown a great reduction in swelling and shrinkage behavior of the expansive soil.

Parte Shyam Singh and Yadav R K (2014) presents the results of a laboratory study undertaken to investigate the effect of marble dust on the index properties of black cotton soil. The test results shows a significant change in the consistency limits of samples containing marble dust .The liquid limit would decrease from 57.68% to 33.9%. The plasticity index decreased from 28.35% to 16.67% and shrinkage limit increased from 8.06% to 18.39% with the addition of marble dust from 10% to 40% of the dry weight of black cotton soil.

P V V Satyanarayanan e.tal (2013) has attempted to utilize fly ash in expansive soils and verified their behavior. Tests like compaction, UCC and CBR were performed on the mixes and identified that addition of flyash increases the strength and decreases the swelling characteristics. From the test result it is also identified that high strength svalues were also obtained at plastic limits. An addition of 20-30% of flyash needed to stabilize expansive soil are used as subgrade and other construction materials in geotechnical applications.

Sachin.N.Bhavsar and Ankit.J.Patel (2012) conducted laboratory tests for the determination of Atterberg's limits, particle size distribution by wet sieve analysis, free swell index, and linear shrinkage on the sample of 50 % black cotton soil + 50% marble powder. They were able to mark a great improvement in engineering properties of black cotton soil by stabilizing it with 50% of replacement by marble powder. Their work aimed to reduce the expansion of expansive soils by using marble dust and to notice the change in index properties of soil samples with increasing percentage of marble dust. Their results showed a great reduction in swelling and shrinkage behavior of expansive soil.

B. A. Mir, Associate Professor, Dept of Civil Engg., NIT Srinagar, conducted a study where high-calcium and low-calcium flyashes were used to investigate the effect of flyash on the swelling potential of Black Cotton soil. According to the results he obtained, he summarized, that the addition of flyash to Black Cotton soil decreases the free swell index, swell potential and swell pressure. There is a considerable reduction in the swelling potential as the amount of flyash added increases. With duration of curing, swelling potential/pressure further decreases. It has been observed that 10 % of Neyveli flyash (Class C fly ash) is the optimum amount required to minimize the swell potential compared to 40 % of Badarpur flyash (Class F fly ash).

Akshay Kumar and Radhikesh (2011) conducted tests on the marble dust on expansive soil stabilized with optimum percentage of Rice Husk Ash. The UCC, soaked CBR of rice husk ash stabilized expansive soil increased upto 20% addition of marble dust. The MDD and Swelling pressure goes on decreasing and OMC goes on increasing irrespective of the percentage of addition of Marble dust on rice husk

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stabilized expansive soil. For best stabilization effect the optimum proportion of soil: rice husk ash: marble dust is 70:10:20

P.G.Greeshma (2011) conducted studies on Kuttanad clay using rice straw as reinforcement. The rice straw fibers of random length added in percentage of 0.25, 0.5, 0.75 and 1. It was observed that unconfined compressive strength of soil reinforced with 0.5% untreated straw of random length shows an increase of 1.94 times with respect to that of unreinforced soil.

III.OBJECTIVES OF STUDY

- To find out the initial properties of collected sample.
- To find out the OMC and MDD of saw dust, coir pith and marble dust incorporated with virgin sample.
- To find out the deviation in swelling pressure when these three materials are added to the sample.
- To find out the deviation in UCC values when saw dust, coir pith and marble dust added to it.

IV SCOPE OF STUDY

Expansive soil deposits occur in the arid and semi arid regions of the world and are problematic to engineering structures because of their tendency to heave during wet season and shrink during dry season. Using land having soft soil for construction lead to various ground improvement technique such as soil stabilization and soil reinforcement.

Many problems arise from the industrial development. Generally, industrial waste causes many serious environment problems. So utilization of industrial waste in construction industry is the best way to dispose it. Using industrial waste in construction industry is beneficial in many ways such as disposal of waste, saving biodiversities, increasing soil properties like strength, reduce permeability, etc., preserve the natural soil and making economical structures.

In this study, saw dust, coir pith and marble dust will be utilized as waste materials in order to lower the swelling characters of such expansive soil. As the open disposal all three material can cause environmental pollution. As the increased application of wood and coir is increasing day to day their waste also increases and it can be severe in future. So it is necessary to find a proper method of disposal other than open disposal. In this study the application of these wastes in reducing their swelling potential of expansive soil and also strength is checked. Thus its application in light weight structures and other smaller applications like bund making, sideways, driveways, etc.

Marble Industry is one of the major industrial production and its waste material marble dust disposal is another major problem facing. They cannot be applied to many areas as they are chemically active in some cases. In this study, it is also checked the effect of marble dust on reducing swelling pressure of expansive clay and also its strength is calculated in order to find out its application in engineering field.

V. MATERIALS USED

A.SOIL

The soil used for the study is clay collected from Chittoor region Palakkad at a 1m depth . Soil was partially air dried and powdered to a fraction less than 4.75 mm. Table I shows the properties of soil.

Table I.Properties of soil

Properties	Results
Field moisture content(%)	90
Maximum dry density(KN/m²)	14.4
Optimum moisture content(%)	29
Specific gravity	2.42
Clay content(%)	56
Silt content(%)	36
Sand content(%)	8
Liquid limit(%)	60
Plastic limit(%)	26
Plasticity index(%)	34
IS classification	MI Soil
Shrinkage limit(%)	8.3
Unconfined compressive strength(KN/m^2)	10.95
Free Swell Test(%)	60
Swell Pressure(KN/m²)	78

B. SAW DUST

The saw dust used for the study is collected from locally available Timber milling factory. The saw dust was air dried to remove moisture from it.

C.COIR PITH

The coir pith was collected from nearby local region where coir factory is working .The coir pith was air dried to remove moisture.

D. MARBLE POWDER

The marble powder was collected from a Chennai Industry having marble quarying.The chemical and physical properties of marble have been collected from them.

VI.*EXPERIMENTAL* SETUP AND METHODOLOGY

Standard Proctor Compaction, Unconfined Compression Test and Swell Pressure Tests were conducted to obtain the strength and swelling characteristics of soil and soil mixed with 2%.4%, 6%, 8%, 10% and 12% of saw dust, coir pith and marble dust.

A. STANDARD PROCTOR COMPACTION TEST

Standard Proctor compaction test is done to assess the amount of compaction and water content required for the sample. The test is conducted as per IS 2720 (Part 7). The Proctor compaction test is a laboratory method of determining the optimum moisture content at which a given soil will become most dense and achieve its maximum dry density. In this study compaction test were conducted with unreinforced soil and soil reinforced with varying percentage 2% to 12% of saw dust, coir pith and marble dust. The main purpose of doing compaction is to find out the OMC and MDD of each sample because the sample preparation of swell test is by this OMC.

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B.UNCONFINED COMPRESSION TEST

The test is conducted as per IS 2720 (Part 10): 1991. The Unconfined Compression Strength tests were conducted on the unreinforced soil and soil reinforced with the varying percentages of saw dust, coir pith and marble dust. All the specimens were prepared corresponding to optimum moisture content and maximum dry unit weight values.

C.SWELLING PRESSURE USING CONSTANT VOLUME METHOD

Swelling pressure test was conducted in accordance with IS: 2720 (PART II) -1973. The sample was prepared as like compaction after finding the optimum value of OMC and MDD of each sample. The varying percentages from 2% to 12% of saw dust, coir pith and marble dust were added to the virgin soil and the swelling pressure at the seventh day was calculated.

VII.RESULTS AND DISCUSSION

A. COMPACTION CHARACTERISTICS

From the Fig.4.1, it is observed that the maximum dry density is decreasing with increase percentage (2%, 4%, 6%, 8%, 10%, 12%) of saw dust and coir pith. It is mainly due to the lower specific gravity of saw dust and coir pith. The MDD has been decreased to 1.2 and 1.6 times of unreinforced clay sample when 12% saw dust and coir pith added respectively.

The dry density value decreases from 14.4 KN/m² for sample to 9.8KN/m² for sample stabilized with 12% coir pith mixture. This is because coir pith being a very low dense material, with increased percentage in sample, reduces the density of the mixture and as good water absorbent it can have a good binding property with clay particles. The addition of marble powder in clayey soil increased the maximum dry density of the soil and decreased the corresponding moisture content values. The dry density increases 2.2 times and the corresponding moisture content was reduced to 1.4 times of unreinforced clay sample when 12% of coir pith added.

The optimum moisture content value increases 1.8 times for sample stabilized with 12% coir pith mixture. This is because coir pith being a good water absorbing material absorbs more water with increase in percentage of coir pith in sample. This additional water reduces the dry density as it occupies the space of clay particles and is shown in Fig. 4.1.

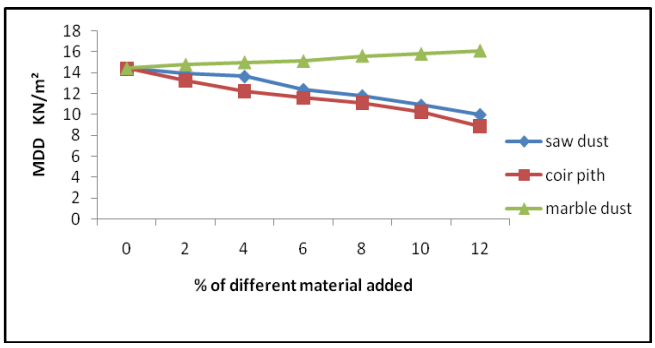

Fig. 1 Graph showing variation of MDD with saw dust, coir pith and marble dust

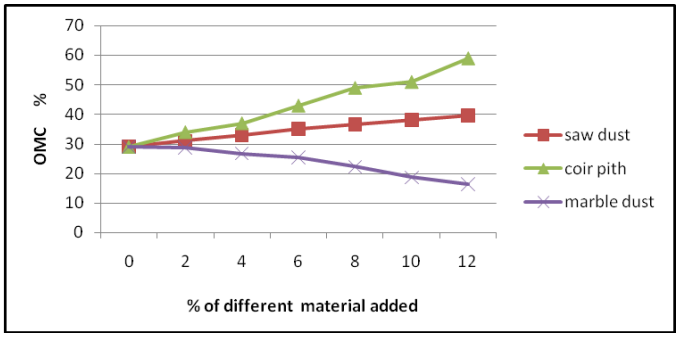

Fig. 2 Graph showing variation of OMC with saw dust, coir pith and marble dust

B. SWELL PRESSURE

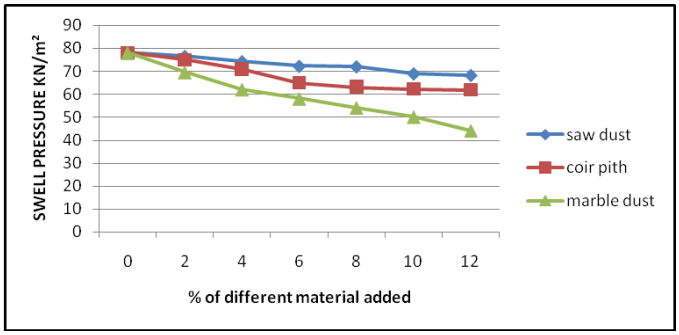

Fig..3 Graph showing the variation of swell pressure with saw dust, coir pith and marble dust added

It is seen that the percentage increase of three of the selected material causes the decrease in swell pressure. The interaction between clay that is necessary for swelling is reduced quite effectively by the increased addition of non plastic saw dust. Surface area and water affinity of the sample decreases which results in the reduction of swelling pressure. Fig 4.3 shows the reduction in swell pressure when various percentage of saw dust (2%, 4%, 6%, 8%, 10% & 12%) was added to the sample. After the 8 % addition of saw dust it only shows slight variation of swelling pressure.

It is seen that the percentage increase of coir pith also causes the decrease in swell pressure. The interaction between clay particles that is necessary for swelling is reduced quite effectively by the addition of non plastic coir pith. Surface area and water affinity of the sample decreases which results in the reduction of swelling pressure.

The coir pith absorbs water, from the sample and reduces the swelling pressure of the sample. As water is absorbed by coir pith, less water reacts with the montmorillonite mineral and the expansion of the soil sample reduces.

The swell pressure of sample obtained was 78KN/m^2.The coir pith absorbs water, from the sample and reduces the swelling pressure of the sample.

It is seen that the percentage increase of marble dust also causes decrease in swell pressure. The reason of this effect is the pozzolonic reactions of the calcareous material present in them react with the amorphous siliceous of soil material. The decrease of swell pressure is also due to the increased surface area of marble powder which reduces the clay particle to particle interaction.

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C. UNCONFINED COMPRESSIVE STRENGTH

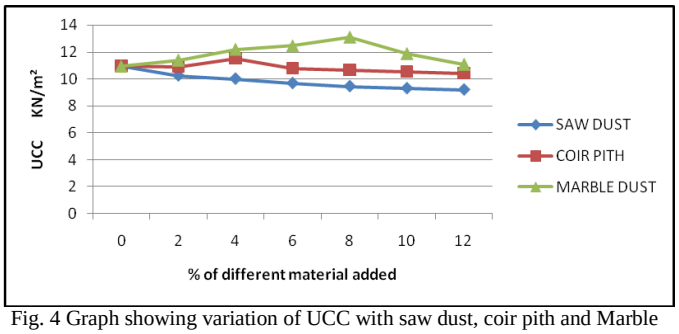

Fig. 4 Graph showing variation of UCC with saw dust, coir pith and Marble dust

From the graph it is clear that the UCC values are decreasing due to the varying addition of saw dust. Dominance of saw dust characteristics in clay-saw mix exhibit the behavior of sawdust. Reduction in UCC occurs due to reduction in cohesion because of the reduction in expansive soil content and due to the lower specific gravity of saw dust. The UCC value decreases upto 1.2 times of sample at the 12% addition of saw dust.

The change in values of unconfined compressive strength is due to the formation of shear planes at different positions for different samples. As the shearing area changes, the position of shear plane also changes hence the UCS values also changes. As the shearing area increases, the Unconfined Compressive Strength also increases. With increased percentages of coir pith in sample, the coir pith acts as a reinforcing material, the shearing area increases and hence the highest value of 11.56KN/m^2 is obtained at 4% addition of coir pith. The decrease of UCC is because of the reduction in cohesive force which was due to decrease in clay content as coir pith occupies its place.

There is 1.4 times increase of UCC of the virgin soil by the addition of 8% marble dust and after that decreases. The reason for this effect maybe due to the pozzolonic reaction of calcareous material present in Marble dust with the amorphous siliceous present in soil. After 8% addition of Marble dust, the strength decreases because of the availability of extra calcareous which results in carbonation reaction and strength decreases.

D. INTERPRETATION OF RESULT ALLTOGETHER

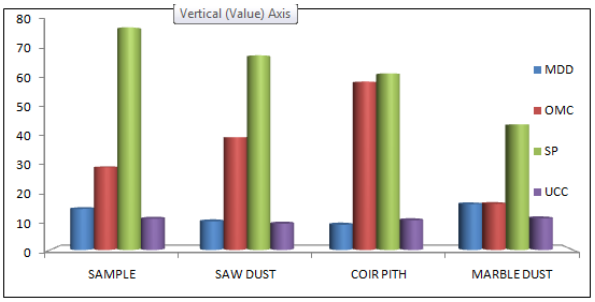

Fig..5 Graph showing the behavior of saw dust, coir pith and marble dust in MDD, OMC, SWELL PRESSURE & UCC

From the above graph it is evident that the addition of saw dust in varying percentages from 2% to 12% decreases the MDD values, this is due to the decrease in the specific gravity of saw dust than the sample. The increase in OMC is due to the absorption nature of sawdust. The decrease in nature of UCC is the dominance of sawdust in the sample. The decrease in swell pressure is due to the insufficiency of clay particles to swell because of the higher dominance of sawdust.

Another environmental issue causing agent coir pith also shows similar nature of saw dust in case of MDD and OMC. But there is an optimum value for UCC shown by coir pith in 4% addition ,maybe due to the high water absorption nature of coir pith it create a bond with the sample. The decrease in swell pressure is due to the absorption nature as well as the dominance coir pith character.

Due to the increased application of Marble in construction field, the amount of marble waste disposal is also an challenging phase for civil engineers. From the graph the MDD values are increasing due to the higher specific gravity of the marble dust and also OMC is decreasing. The interaction between clay particles that is necessary for swelling is reduced quite effectively by the addition of marble dust.

Marble dust have potential to provide multivalent cations which promote flocculation of clay particles by cation exchange .Therefore ,the surface area and water affinity of the sample decreases which result in the reduction of swelling pressure. The UCC value is optimum for 8% addition of marble dust. The reason for this effect maybe due to the pozzolonic reaction of calcareous material present in Marble dust with the amorphous siliceous present in soil. After 8% addition of Marble dust ,the strength decreases because of the availability of extra calcareous which results in carbonation reaction and strength decreases.

VIII.CONCLUSIONS

Based on extensive laboratory tests conducted on expansive clay mixed with saw dust, coir pith and from 2 to 12% by weight of dry clay, the following conclusions are drawn:

- Addition of saw dust and coir pith increases the optimum moisture content and decrease the maximum dry density. The decrease in maximum dry density is due to the lower specific gravity and increase in OMC is due to the absorption nature of both
- Addition of saw dust and coir pith decreases the swell pressure. This is due to the decrease in the interaction between clay and water which is necessary for the swelling.
- The UCS of the saw dust stabilized expansive clay decreases due to the reduction in cohesive force. This happens because of the dominance of sawdust character.
- The UCS value of coir pith stabilized expansive soil increases up to 4% and thereafter decreases. The decrease due to the reduction of clay to clay particle interaction with increased addition of coir pith.
- Therefore considering both the factors, i.e., swelling pressure and unconfined compressive strength, it can be concluded that 4% addition of coir pith in sample can be selected as the optimum percentage of coir pith to be added

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- Addition of marble dust increases maximum dry density and reduces optimum moisture content. The UCC value increases upto 8% and thereafter reduces.The reduction is due to the higher surface area of the marble dust.
- From the above laboratory investigation it can be concluded that the waste materials like saw dust, coir pith and marble dust has a potential to modify the swelling characteristics of expansive clay and to make it suitable in many geotechnical applications.

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